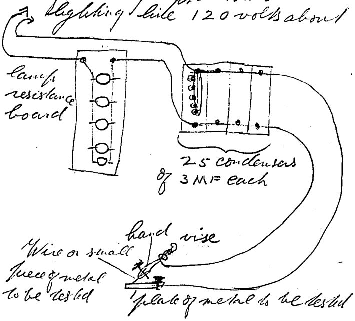
Notebook, N-07-06-18

Experiments on the ventilations
of the different metals under
the electric spark.

June 18. 1907

A Mc Glaister

To cause the scintillations use the following apparatus


lighting line 120 volts about
lamp resistance board
25 condensers of 3 MF each
hand vise
Wire or small piece of metal to be tested
plate of metal to be tested

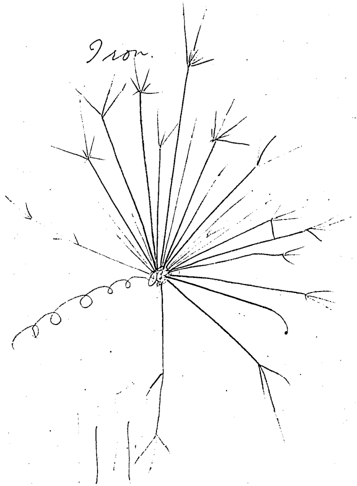
Used 1 16 candle power lamp on the board & 25 condensers of 3 MF each making 75 MF in all

Iron

used a piece of clean sheet
iron & a piece of fine iron-wire.
With this metal the blue spark
round the terminals is comparatively
small
The scintillations are long almost
all straight till near the end
where they fork ~~and~~ the straight
portion is a bright white or slightly
yellow colour the side branches
that fork off are red & quickly
become dull red they are generally
straight & in some cases show
dark spaces, some of the scintillations
do not show forks & in this case
they almost always show a dark
space near the tip
Where the surface of the metal
is clean the scintillations are less
in number & shorter than where there
is a slight film of oxide and with the
clean metal the terminals show
a great tendancy to weld, there is
absolutely no smoke with these
scintillations ×

× When I threw the arc light
on the terminals I could see
a haze of smoke but much
less than with Cu or Mn.
The scintillations show no deviation
with a strong magnet

Iron.



with clean surfaces the scintillations would average two or three inches but where there was a film of oxide they would be thrown out as far as 12 inches or more

Now & then an exceptionally large scintillation would end in a little bead of metal

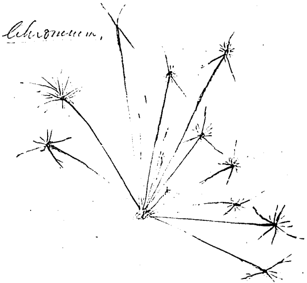
~~In no case did I find any scintillations that forked from more than one point~~, the end of the main scintillation was just as thick & bright as the beginning but it did not show any tendency to beading

~~Tried cast iron & tool steel but did not find any appreciable difference~~

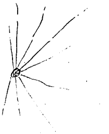
~~also~~ noticed the spark from iron on an emery wheel & found it to have the same general character the only difference being that most of the sparks were brighter at the end than at the beginning in some cases they were brighter after the fork than before.

Now & then Iron throws off a spiral but it is only very seldom, the spiral is much coarser & more decided than Iron

Chromium,



In hydrogen could not be distinguished from iron shows no forks but o distinct dark spaces



The scintillations show no deviation with a strong magnet

Chromium.

Used pure fused chromium.

The scintillations from this metal bear some resemblance to those from iron but there are some marked features of difference,

The scintillations begin straight as with iron and at a certain point they branch out forming more branches than with iron & the end of the straight part is generally thickened or even ~~beaded~~ beaded

The main branches at the point of forking show~~ed~~ ~~[illegible]~~ a tendency to leave the first thick line at a higher angle than in the case of iron

This metal gives a slight amount of smoke in thin curling lines & these are light up from the blue light of the spark & look almost like a brush discharge

I could never observe this effect on the first discharge so it was probably the spark lighting up the smoke from a previous discharge

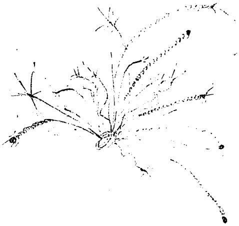
Occasionally a very large spark would show signs of re branching on one of the large branches.

Some of the bigest sparks did not seem connected with the blue arc but would be thrown out say half an inch before they would show as a white line.

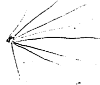
Most of the fine branches showed slight dark spaces at the tip then a brighter piece then before like a little wedge

In colour & intensity the Cr cannot be distinguished from Fe the principal difference is in the formation of a bead at the point where the main line branches & in the larger number & more obtuse angle of the branches. The clean terminals of chromium show some tendency to weld but not as much as those of iron.

Manganese



In hydrogen no trace of revolution visible no ~~[illegible]~~ forks no black spaces dull red could not be distinguished from carbon



The scintillations show no deviation with a strong magnet.

Manganese

The scintillations from this metal are like those of iron in colour & intensity but they differ in that they are almost all curved & twisted & the particles thrown off seem to be larger & can be seen to be revolving there is considerable smoke which forms long spiral lines owing to the revolving particles

most of the scintillations are forked but not nearly so much so as chromium, owing to the crumbly nature of the metal the spark loosens little fragments which are scattered all round

most of the bigger scintillations do not show luminous till a little way from the ~~face of metal~~ metal terminal

Sometimes quite large particles are thrown off which show up as a revolving ball of ~~fire~~ & remain luminous till they strike the desk the scintillations that fork are beaded like those of chromium but they do not form as many branches

Many of the scintillations go almost

straight & appear very faint then they take a sudden bend & become much brighter

There are quite a number of the smaller ones which do not branch but end off with a slight bend then a dark space & a little red tip.

Some may be seen at first as a thin straight line then they get thicker & show signs of revolving.

The number of curved scintillations & the appearance of revolving particles at once distinguishes manganese from either iron or chromium

The terminals with them do not weld but on the other hand they crumble away.

The difference between the scintillations of this metal in air & in hydrogen is most striking in the latter there is no trace of the appearance of revolving no branches & the light is very dull red no dark spaces visible The hydrogen does not prevent the smoke formation

Aluminium

Al 1

This metal shows two distinct kinds of scintillations

I large brilliant blue lines which begin straight then suddenly twist back on themselves & change to thin curved & twisted lines of dull red

II small scintillations which are thrown out as red lines from the first and are very dull in colour compared to the others.

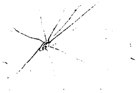
The larger scintillations show great variety in the way they finish. The greater number twist upon themselves & become red & very crooked but remain as a single line without forking. Others show two or three distinct branches at the point where the blue turns into red while here & there one may be seen to throw off branches while it is still coloured blue.

Most of the large blue scintillations show signs of revolving.

This metal shows some smoke but very little hardly enough to be noticeable without the arc light

Aluminium in hydrogen

all straight lines no branches
dull red no trace of the
blue scintilations which are shown
no dark spaces visible



Al_3

In some cases the beaded appearance due to revolution shows only in the small red forks but does not show in the blue line at all

Sometimes with the more prominent scintilations the point where the blue changes to red seems to be surrounded with a red light like a pale flame.

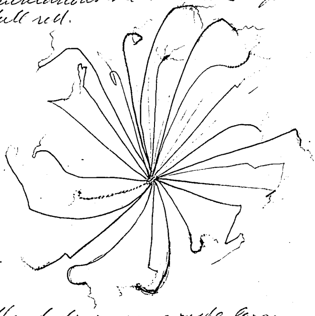
When the al is used as terminals in the black discs for photography the Al_2O_3 formed seems to be attracted by the static charge in the discs & bridges across the gap in fine threads

Most of the largest scintilations of aluminum seem to be enveloped with a sort of flame which gives off so much light that it kills much of the detail at the end of the scintilation

The spark at the point of contact is large & bright blue in color.

Aluminum

The thick lines represent the blue scintillations the thin lines represent dull red.



The shading on some of the large scintillations is meant to represent an envelope of flame which hides a good deal of the fine details at the tip of the scintillations

~~without the arc light~~.

Al_2

The terminals have considerable tendancy to ~~stic~~ weld when they are clean.

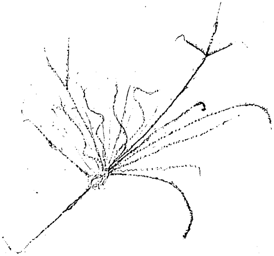
When the terminals used are clean there is not much blue spark and there are comparatively few of the red scintillations when the terminals are dirty there is a large blue spark & a great many dull red scintillations with just a few blue but these blue ones are very large & brilliant

The greater part of the large blue scintillations are straight at first & many turn red at the point before they commence to burst while others burst while still blue then fade into red

Many show some forks after they turn red & a few show quite an explosive bead like Cr.

Some of the scintillations have a beaded appearance the whole length of the blue due to revolving others show continuous till near the end then show the revolving just at the termination

Magnesium



In hydrogen
Gives very few scintillations but what few it gives are quite straight & dull red there is distinct smoke formation

What scintillations there are are very short

Magnesium.

The scintillations of this metal are very similar to those of aluminium the principal features of difference being that they show much more of the beaded & spiral appearance due to revolving and they have more tendency to curve & twist. Like aluminium the principal scintillation is blue & at the end changes to red but both the blue & the red portions show revolving.

Like Al most of the large scintillations show an envelope of flame which tends to hide the fine detail

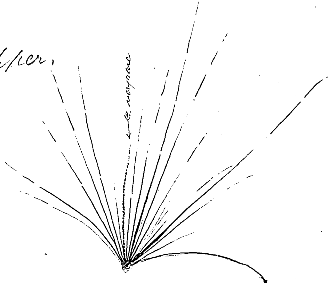
Also like Al the oxide formed when the two terminals are between the black discs, is attracted by the static charge & forms threads across the gap.

The spark at the point of contact of the terminals is bluish green in colour. Even with clean metal the terminals show very little tendency to weld when held between the brass springs

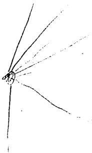
they may be pressed together & will give a small arc for some time without any tendency to stick. The Mg scintillations show much more tendency to fork than those of Al. some seem to come to an explosive head like Fe.
If a number of sparks were made in quick succession among the smoke could be seen little silvery particles of metal ~~burst~~ lighted up from the flash of the following spark.
Magnesium seems to crumble under the spark but nothing like the same extent as tin there are small fragments all scattered over the bench but they are much smaller than those from tin this metal seems to show even greater variety than aluminium some of the scintillations are very much twisted & others are straight & thick some show much forking & even an explosive head while others do not fork at all but all even the finest red ones show some signs of spiral revolution.

The photographs showed quite frequently a tracing that started thick then came to a shoulder & continued thinner having an appearance like the tracing on a phonograph record.

Copper.



In hydrogen showed almost the
same the colour a darker red
Sometimes the spark was surrounded
with a scarlet envelope as with
[illegible]
but saw this
in air also
so it is not
connected
with the
hydrogen



Copper.

The scintillations of this metal
are quite different to any of
the previous ones.
The spark at the point of
contact is small and bluish
green in colour
The scintillations are a dull
red colour & very long at times,
when the spark is made
between two points they may
fly out two feet, the scintillations
are all straight are only very
slightly curved like a
paraboloid and they show
no forks they start thick
and gradually become thinner
till they are quite fine then
there is a very distinct dark
space sometimes ¼ of an inch
long then the light began
again & might be quite thick at the
base & dwindle down again to
form another dark space & a second
or even a third length up

The clean terminals show some tendency to weld but not as much as Fe

There is some smoke formed but not enough to be very noticeable except in a bay of arc light the smoke does not form threads

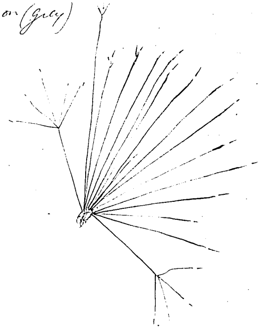
The ~~[illegible]~~ scintillations are thrown off in a more distinctly radial direction than with some of the other metals there is very little tendency for them to cross one anothers paths

Occasionally there is a scintillation which shows a beaded appearance throughout its whole length but these are comparatively rare

Tried several photographs but could not get anything that showed the characteristics as the copper scintillations are such a dark red colour

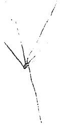
Copper in oxygen is just the same as in air ~~[illegible]~~ except that it is a mere trace brighter but in shape & character it is just the same

Cast Iron (Grey)



In hydrogen

Very dull red no dark spaces visible. no branching visible



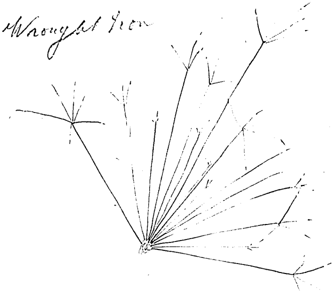
Further work on Iron

Did some further work on Fe to see the difference between cast & wrought iron & different forms of steel. Also tried to deflect the scintillations of Fe with a powerful electro magnet but found it had absolutely no effect.
There is a distinct difference between cast iron, wrought iron, & tool steel but could not notice any appreciable difference between wrought iron & machine steel

Grey cast iron

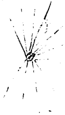
The noticeable feature about cast iron is the very small indication of scintillations that fork. Most of the scintillations thicken a little at the end & then have a dark space & a very small dash on the tip

Wrought Iron



In hydrogen.

Dull red no branching visible but dark spaces very noticeable



when there is a forked one the forks are usually very large & spread out irregularly after the fashion of a fan.

Wrought Iron

This differs from cast iron in the greater number of scintillations which show forks

Machine steel.

Could not notice any difference between machine steel & wrought iron.

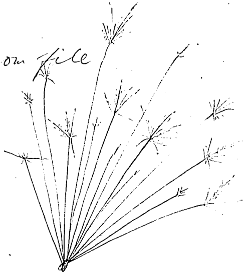
Tool Steel (rod)

The difference between wrought iron & untempered tool steel were only very slight the forks of the scintillations were slightly more inclined to be feathery

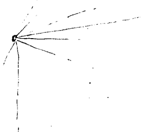
Steel from file

This was more distinctly feathery at the end of the scintillations than the piece of rod tool steel.

Steel from file



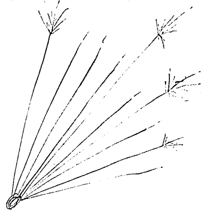
In hydrogen no branches visible dark spaces quite distinct sometimes the blue spark is surrounded with a bright red envelope



each scintillation had more small branches at the end than was the case with wrought iron

Effect of tempering
Broke a file into 6 pieces heated two red hot & plunged into water = glass hardened heated two more pieces & allowed to cool slowly = drawn kept the other two pieces as they were.
Cleaned up the surfaces on an emery wheel & tried the difference in the scintillations but could not detect any difference in the character the two pieces that were drawn showed the most tendency to ~~[illegible]~~ weld and their scintillations were not quite as long as with the others.
The scintillations from the file steel are much more stellar than are those of wrought iron

Self hardening Steel



Self hardening steel

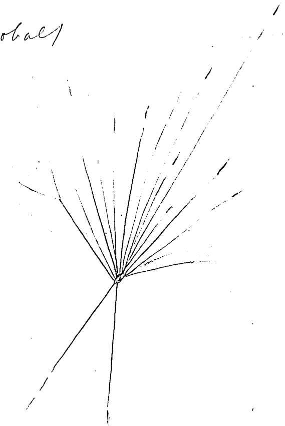
The scintillations of this are of two kinds some without any forks like the predominating ones in cast iron & others that have many branches & are feathery like the file

Effect of an atmosphere of hydrogen.

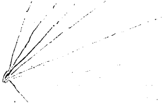
I had a wooden box made with 2 glass sides put the discs containing the metal terminals in this passed dry hydrogen in at the top & out at the bottom into an inverted test tube to prevent diffusion made the spark by means of a stick going through the box & connected with one of the springs carrying the disc. I found that the hydrogen made an enormous difference tried wrought iron first instead of being bright yellow the scintillations were only a very dull red & showed absolutely no forks but were only short lines with a number of dark spaces looking like a discharge of small condenser through

Ofeser.

Cobalt



In hydrogen looked just like
copper does in air
showed no forks
dark spaces plain
dull red



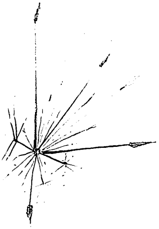
Cobalt

The scintillations of cobalt bear considerable resemblance to those of cast iron but in the case of cobalt there are even fewer forked scintillations the most characteristic scintillation showed one straight scintillation which gradually became thinner then there was a very short dark space & a dash added on at the tip that was as thick or thicker than the first part of the scintillation Then there were others which showed several ~~scintillations~~ dark spaces & the ~~little~~ dashes were not as thick the scintillations of this class were almost exactly like those of copper except for a difference in colour they were not quite so dark a red. Then again there were some scintillations which showed forks but the forks were different from those of iron the branches did not as a rule fly out at such a wide angle & the forks were usually as thick as the straight line they came from but were not so bright in colour these branched scintillations were comparatively rare

there was very little smoke with the cobalt spark less if anything than with iron some of the scintillations showed a very slight signs of revolving the spiral was very close & needed much looking for to observe it at all.

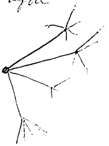
Cobalt shows the strongest tendency to weld of any metal tried yet. between clean terminals the spark makes them stick so that it is quite difficult to pull them apart

Iron in Oxygen (Wrought Iron)



File steel in oxygen. ×

× Tried this again but found [illegible] branches next time must have been some air left before



The forked scintillations were longer than with soft iron

Iron in Oxygen. (Wrought Iron)

In oxygen the characteristics of the scintillations of wrought iron are altogether altered they are brighter but shorter & show very much less tendancy to fork on the other hand most of them end with a little dash thicker & brighter than the rest of the scintillation & this dash often has jagged edges looking like the head of a savages spear those scintillations that do fork much are generally very short & bright and end slightly explosive with a bead like chromium in air.

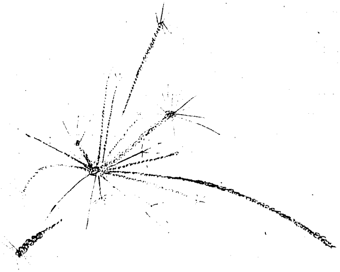
The scintillations tipped with the rugged dash are generally very thick. some of the branches of the scintillations show a slight tendancy towards being spiral

There was slight evidance of smoke formation

Steel in oxygen (File Steel)

This showed more tendancy to fork the forks were very slight there was not much evidance of the dagger ends like soft iron showed.

Mn in O.



distinguished from Cr.

Chromium in Oxygen

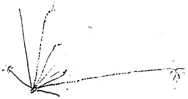
The character of the scintillations is not much altered by oxygen they show brighter & perhaps a rather larger proportion do not fork but the greater number show an explosive head & fork just as they do in air.

Manganese in Oxygen.

The oxygen makes a wonderful difference in the scintillations of Mn. they are very bright and thick and though still spirals do not show as much tendency for irregular twisting as in air and at the tip they have a regular fan of fine branches some of these thick scintillations show no connection with the terminals at all but begin thin & gradually get thicker till they burst. The main scintillation is a vivid white & the star of branches a fairly bright red while some of the scintillations show the spiral very well others look quite straight & could not be

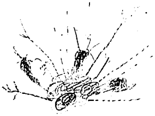
Al in O

Colour a very bright blue with red points at the tips.



Aluminium in O.

This metal burns so quickly in O that most of the scintillations are much shorter than in air they are all much brighter & of a more decided blue colour. There is very little tendancy to double back on themselves & form hooks as in air on the other hand many of the large scintillations seem to explode & branch at the point as they hardly ever do in air. The tendancy to form spirals is more marked than in air. There are practically no red scintillations all are blue but the tips & branches are still red. These scintillations in O look more like Mg in air. Quite a number of the scintillations end off without any change simply a blunt end to the straight blue scintillation. The spiral tendancy & formation of explosive point are neither as marked as with Mn but are much more noticeable than with Al in air mg in O



Magnesium in O.

It is difficult to get any large scintillations of mg in O it burns so readily that one only gets a brilliant flame round the terminals this flame illuminates the smoke so strongly that it shows up in the photographs but sometimes very large scintillations can be obtained as a sort of irregular continuation of the ovoid flame round the terminals, and occasionally there would be thin scintillations showing the characteristic spiral ascen in air but they would all be straight not twisted all ways as in air. Sometimes there would be a thin bright line with three or four thicker brighter patches on it like beads.

I had one night often make 8 or 9 sparks before getting any scintillations at all

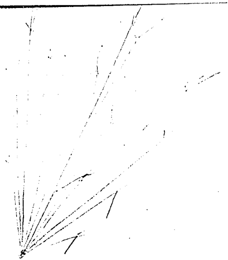
In Air & Oxygen

Tried Fe Al & Mg in a mixture of about 2 parts air & 1 part O. The Fe gave all the characteristics of pure O except that the scintillations were not quite so bright & a trifle longer

Al gave characteristics intermediate between those of air & pure O the scintillations were longer than in O & brighter than in O air they were in a good condition to photograph the ends of the scintillation in some cases finished off just as in air & in other cases showed an explosive tip as in O there was more tendency to form spirals than in air

Mg also gave characteristics intermediate between air & O the large irregular blue flame was there but was smaller than in O & there was a larger proportion of the typical twisted spiral scintillations

Fe in Cl.

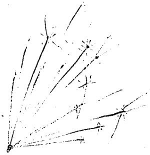


Colour a dull yellowish red. characteristics almost the same as in air.

Fe in Chlorine

Filled ~~with~~ the sparking box with dry Cl_2 (generated from HCl & $KMnO_4$ the gas must be dry or it very soon obscures the glass) & made the scintillations of Fe in this gas the scintillations were both very numerous & very long and it was much easier to get a big spark than in air They were not quite so bright as in air & the colour of the Cl cut off some actinic light but had no difficulty in getting photographs The characteristic forking was just the same as in air & the photographs could not be distinguished from those made in air the principal difference lay in the clouds of smoke that each spark made after 5 or 6 sparks the glass began to get obscured too much to photograph more

Chromium in Chlorine

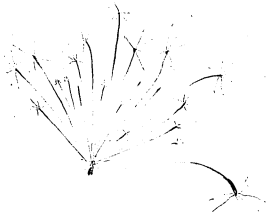


Rather longer than in air
colour dull yellowish red

Chromium in Chlorine.

The scintillations of chromium in chlorine are very numerous & long as is the case with iron in fact you can get a big splash of sparks in chlorine every time while in air sometimes the scintillations are almost absent. The chlorine scintillations are dull red & longer on the whole than in air but the general characteristics are the same as in air the tip of the scintillation ends in an explosion and throws out branches exactly as it does in air, the scintillations were too dull to get good photos. As with iron so with chromium in chlorine dense clouds of smoke are given off from the spark

Mn in Chlorine

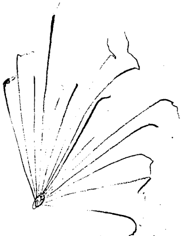


colour & general characteristics
very similar to chromium in Cl

Manganese in Chlorine.

The scintillations of manganese in chlorine are quite different in character from those in air they more nearly resemble chromium. In colour & brightness they are about the same as iron & chromium in chlorine and they seem to have lost mostly their tendancy to burst & form spirals the larger scintillations have slight curves but the sharp bursts that are found in air are almost entirely absent the scintillations grow brighter the further away they get from the spark ~~&~~ indeed a number of them show no attachment to the central spark at all after careful looking could not see any spirals at all some of the scintillations have a slightly wavy outline but a large proportion of them are quite straight it would be difficult to distinguish with certainty between this metal & Cr in Cl.

Al in Cl



Colour red rather brighter than Fe in Cl. Shape about the same as Al in air.

Aluminium in Chlorine.

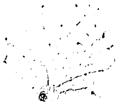
In making the scintillations of Al in chlorine one sees at once the great difference that instead of being intensly bright ~~red~~ blue as in air they are ~~dull~~ red in colour. In size & shape they are about the same as in air.

The scintillations make some smoke but not nearly as much as Fe or Cu.

As in air there are no branches visible or at any rate only very minute ones

Could not detect any indication of spiral formation

Mg in Cl



Colour very slightly blue very bright blue flame round the terminals which illuminates the dense smoke with a blue light

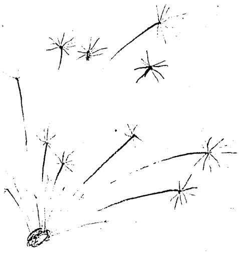
Magnesium in Chlorine

The effect of chlorine on the scintillations is most curious the scintillations in the form of a continuous twisted line as seen in air are very rare & the main number seem to have the dark spaces in the beaded scintillation so enlarged by the chlorine that they no longer appear as a line but as one or in some cases two or three luminous dots. These dots are slightly blue in colour but not nearly so blue or so bright as in air there is a bright blue spark at the terminals & a very dense cloud of smoke formed and among this smoke are scattered all over little detached dots of blue light

The flame blue spark round the terminals was similar to the one formed in O

The few line scintillations that are formed are similar to those in air.

Titanium



Some of the scintillations have hardly any tail at all just an explosive head

Titanium

This element was used in the form of a fine powder as we had no pure titanium in pieces the powder was spread over a sheet of zinc & the spark obtained by using a strip of zinc as the other terminal. Zinc was chosen because it gives practically no spark

The scintillations from this element are very similar to those of chromium the colour is if anything a little brighter and they show more tendency to an explosive fire ball like head. Quite a large number of the scintillations show no connection with the point of contact on the zinc plate they may travel for about 2" before they become visible then they begin as a fine dull red line constantly thickening & getting brighter till they burst There seemed to be no appreciable smoke, I ~~never~~ was never able to observe a dark space followed by a light dash as seen in Cr. or Fe

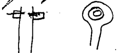
[THIS BOOK WAS USED IN BOTH DIRECTIONS. THE FOLLOWING PAGES WERE FILMED FROM THE BACK END FORWARD.]

Methods tried to photograph the scintillations.
Tried first with Fe
No 1 took 1 discharge about 2 feet from lens at F 11 very little picked up at this stop
Tried again at full opening & about 18" away this showed much more exposure but very little depth of focus being so near at that large stop
Found the best way to focus was to use a candle flame just in front of the Fe plate & focus from $\frac{1}{2}$" to $\frac{3}{4}$" forward the distance which gave about the best compromise was about 20"–23"
Took Fe, Cu, & Mn, under these conditions.
Took Fe & then Al with the reflex at $\frac{1}{500}$ of a sec very little showed with Fe but with the Al got some hairings about 1" long

Speed of fan motor
no load on

I notch on resistance about 1800
II — 2200
III 3100

Fit up some brass shells on
springs to cut out the spark &
those of the scintillations going much
out of perpendicular the diam of



the discs was $\frac{3}{4}$" & at the time of
spark they were about $\frac{1}{8}$" apart
used the front bellows of the
camera fully extended &
focused by moving the whole
camera the distance from
the terminals to the front lens
was about 16" this gave a
picture about natural size
later on got new 4x5 camera &
& 7" helier lens set this at the
position to give a picture just
natural size
later on had to try the scintillations
in different gases for this enclosed the
discs in a box with glass windows with
gas inlet & outlet tubes & a stick
arrainged to touch the terminals
together

Method of making Plates
Red Sensative
By Arthur Payne
Photo Era

Bathe the plates for 3 minutes in a solution of
Pinacyanol 1 in 1000 alcohol) 2 cc
Dist H_2O 100 cc
This should not be used more than once
Wash the plates for 3 minutes wipe with pad of cotton & dry.

Green safe light for use with above plates
The following solution used in a cell 1" thick.

Acid green	2 parts	Dilute with 25 parts of H_2O
Naphthol green	2 parts	
Tartrazin	15 parts	
Dist water	300 parts	

Use a sheet of ground glass in front of the cell

Pinacyanol (1 in 1000 alcohol)	2 cc
Dist. water	100 cc

do not use more than once

Green Safe Light

Acid green	2 parts
Naphthol green	2 parts
Tartrazine	15 parts
Water dist	300 parts

Dilute this stock solution with 25 parts of H_2O and use in a cell 1" thick.

In case of necessity the plates do not need to be dried but may be loaded into the plate holder after being wiped off with cotton after exposure they should be soaked about 10 minutes in dist. water to make evenly wet before development.

Even with the ~~red~~ safe light mentioned do not expose the plates to light more than is absolutely necessary.